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The Bank Capital Requirement and Information Asymmetry

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ABSTRACT

This paper recognizes two main factors that cause the capital requirement to affect the weighted average cost of capital and hence the investment behavior of banks: underpriced debt resulting from the deposit insurance and information asymmetry between managers and the stock market. For a bank enjoying a low cost of debt (deposits), an increased proportion of equity financing raises the weighted average cost of capital. When the stock market underestimates the value of a bank due to information asymmetry, equity financing is expensive. This paper finds that banks constrained by the tightened capital requirement grew slower in 1991 and that information asymmetry as well as underpriced deposits played a role in explaining the slower growth.

KEYWORDS: Capital Requirements; Information Asymmetry; Credit Crunch

JEL CLASSIFICATION: G21

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1. Introduction

The increased number of bank failures in the 1980s raised concerns about the riskiness of banks and hence prompted movements for tighter capital requirements. The Basle Agreement of 1988 requires that banks meet the minimum capital ratios of 4 percent tier 1 capital and 8 percent tier 1 plus tier 2 capital to risk-weighted assets by the end of 1992.[1]

The capital requirement, which imposes constraints on the capital structure of banks, can affect the weighted average cost of capital (the average cost of equity and debt weighted by their proportions) and hence the investment decision of banks. The well-known proposition of Modigliani and Miller (1958) and following works [Hamada (1969), Rubinstein (1973), and Hsia (1981)] show that the weighted average cost of capital (WACC) is independent of capital structure when the costs of equity and debt are determined in a frictionless market. In the banking sector, the cost of debt (deposits) is not determined by the market since deposits are insured. In addition, the cost of equity can deviate from market fundamentals when there is information asymmetry between managers and the stock market.

Assuming that deposit financing is cheaper than equity financing due to underpriced

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[1]Tier 1 capital consists mainly of common stock and some perpetual preferred stock. Tier 2 capital includes preferred stock, subordinated debt, and allowance for loan losses. In calculating risk-weighted assets, assets are classified into 4 risk-weight categories: zero percent, 20 percent, 50 percent, and 100 percent risk-weight category. For example, most government securities fall into zero risk-weight category, claims guaranteed by depository institutions are given 20 percent risk-weight, loans fully secured by first liens on residential properties are included in 50 percent risk-weight category, and most other loans fall into 100 percent risk-weight category. Risk weights are also applied to the credit-equivalent amount of off-balance-sheet items.

deposit insurance premiums, using a higher proportion of equity increases the WACC. An increased weighted average cost of capital will narrow the scope of profitable investment opportunities. In this case, the capital requirement limits the banks' ability to take advantage of the option value (banks' risk that is not reflected in the interest rate on deposits) deriving from the deposit insurance. This effect may be the one intended by regulators.

There is a second effect of the capital requirement that may unduly limit the growth potential of banks. Finance literature of the recent years suggests that the cost of equity can be excessively high on occasion. The stock of a firm can be mispriced due to asymmetric information between the management of the firm and the stock market [Myers and Majluf (1984), Miller and Rock (1985), MacKie-Mason (1990), and Korajczyk et al.(1990)]. Managers are better informed about the future cash flow of the firm. Issuing shares at an unfavorable price (below the present value of the future cash flow estimated by managers) dilutes the value of existing shares. Assuming managers have favorable inside information and act in the interest of existing shareholders, they may pass up a good investment opportunity rather than issue shares to finance the investment [Myers and Majluf (1984)]. Given this logic, the statutory capital requirement, which necessitates some equity financing, can restrain banks from pursuing profitable investment opportunities. In this case, we may say that banks are handicapped by the capital requirement which limits the choice among financing alternatives. This effect of the capital requirement is not only undesirable but also disruptive. The investment decision of a bank may change with the degree of information asymmetry faced by the bank. Thus, in assessing the effects of the capital requirement, it

is important to understand the role of asymmetric information.

The findings of previous studies generally support the presence of asymmetric information. They examine the investment behavior of commercial firms and find a positive relationship between the firms' cash flow and investment [Fazzari et al.(1988) and Devereux and Schiantarelli (1990)]. The positive relationship, they argue, indicates the difficulty of external financing that may arise from asymmetric information. Since bank assets, loans in particular, are information intensive, information asymmetry is likely to be more serious in the banking sector than in many other industries producing standardized products. In addition, the effect of information asymmetry will be more pronounced when equity financing is necessary. Thus, the application of this literature to the banking sector may produce more interesting results.

There are many recent studies that look at the relationship between the capital adequacy and growth of banks [e.g., Johnson (1991) and Bernanke and Lown (1992)]. These studies generally find that better capitalized banks grew faster in recent periods. They attribute the finding, at least partly, to the tightened capital requirement, but are not explicit about the mechanism through which the capital requirement affects the investment decision of banks.

This paper explicitly recognizes underpriced debt and asymmetric information as two main reasons why the bank capital requirement matters and tests their empirical significance. The growth of risk-weighted assets of bank holding companies during 1991 is regressed on proxy variables representing information asymmetry and the cost of debt. The empirical test generally supports that underpriced debt and asymmetric information affected

the investment decision of bank holding companies: Risk weighted assets grew slower at banks experiencing more information asymmetry and at banks whose debt was more heavily underpriced. The empirical section also compares publicly held and privately held bank holding companies and finds that asymmetric information more significantly affected the investment decision of bank holding companies whose stocks are publicly traded. This finding may be explained by the difficulty of transmitting information to the stock market.

The rest of this paper is organized as follows. Section 2 presents a model showing the roles of underpriced debt and asymmetric information in causing the capital requirement to affect the investment behavior of banks. The third section discusses empirical methodology and results. Section 4 summarizes the article's findings.

2. Equity Financing and Weighted Average Cost of Capital

This section presents a two-period model that shows how equity financing used to meet the capital requirement affects the WACC of banks. Assuming that deposits are underpriced, increased equity financing raises the WACC and hence narrows the scope of profitable investment. However, as long as the stock market correctly assesses the return from the existing and additional investments of a bank, the WACC does not exceed the level that would be determined by free market forces, i.e., the case of zero option value. Thus, in the absence of information asymmetry, the increased WACC resulting from a higher capital requirement may be desirable in terms of both resource allocation and regulatory efficiency. On the other hand, when there is asymmetric information, the capital requirement can unduly limits the growth potential of banks by excessively raising the WACC.

Suppose a hypothetical bank with the following balance sheet at the beginning of period 1.

Assets	Liabilities
A	D
B	C

A - assets subject to the capital requirement.

B - assets free of the capital requirement.

D - Deposits.

C - capital.

The bank has n outstanding shares at the beginning of period 1. In period 2, the outcome of the bank's investment becomes publicly known, and the share price is determined by the value of capital. For simplicity, corporate and personal income taxes are assumed away. The management of the bank maximizes the present value of its share price by making investment decisions in period 1.[2] In order to focus on the effect of the capital requirement on the bank's investment decision, it is assumed that the bank starts period 1 with the required capital ratio and maintains the same capital ratio. Thus, when the bank undertakes an additional investment, it raises capital equal to the required ratio times the investment.

If the bank does not undertake any additional investment in period 1, the present value of share price is:

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[2]This is equivalent to maximizing the expected wealth of existing shareholders in this model.

$$PV = \frac{(1+r_{A1})A + (1+r_B)B - (1+r_D)D}{n(1+r_E)} \qquad \text{(E1)}$$

PV = the present value of share price (based on the bank manager's information).

r_{A1} = the rate of return on existing A expected by the management.

r_B = the expected rate of return on B (assumed to be constant and publicly known).

r_D = the interest rate on deposits.

r_E = the rate of return on the bank's equity required by the stock market.

The numerator is the expected return from existing assets estimated by the bank management minus payment to depositors, and the denominator is the discount factor times the number of existing shares.

When the bank decides to increase A, it raises the required capital and uses either additional deposits or funds previously invested in B. The choice may depend on the availability of additional deposits. I examine both cases.

Case 1: It is assumed that the bank can increase deposits without bidding up interest rates. The bank finances a new investment that is subject to the capital requirement with newly raised capital from issuing an additional share and deposits. B is assumed to be zero for simplicity.

The price of the additional share,

$$P = \frac{(1+s_{A1})A + (1+s_{A2})\Delta A - (1+r_D)D - (1+r_D)\Delta D}{(n+1)(1+r_E)} \qquad \text{(E2)}$$

s_{A1} - rate of return on existing A expected by the stock market.

s_{A2} - rate of return on the additional investment expected by the stock market.

The price is the value of capital in period 2 expected by the stock market divided by the discount factor times total number of shares.

$$\Delta A = \frac{P}{k} \tag{E3}$$

where k is the required ratio of C to A.

When capital increases by p, the bank can increase A by P/k and still meet the capital requirement.

$$\Delta D = \frac{P}{k} - P \tag{E4}$$

The increase in D is the increase in A minus the newly raised capital.

Substituting E3 and E4 into E2 and solving for p,[3]

$$P = \frac{k\{(1+s_{A1})A - (1+r_D)D\}}{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_D)} \tag{E5}$$

Substituting E5 into E3,

$$\Delta A = \frac{(1+s_{A1})A - (1+r_D)D}{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_D)} \tag{E6}$$

Substituting E5 into E4,

[3]Given the limited liability, i.e., non-negative returns from the existing investments of the bank, the denominator of this expression must be positive.

$$\Delta D = \frac{(1-k)\{(1+s_{A1})A - (1+r_D)D\}}{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_D)} \quad \text{(E7)}$$

The expected change in the present value of share price as a result of issuing an additional share and making investment is:

$$\begin{aligned}\Delta PV &= \frac{(1+r_{A1})A + (1+r_{A2})\Delta A - (1+r_D)D - (1+r_D)\Delta D}{(n+1)(1+r_E)} \\ &\quad - \frac{(1+r_{A1})A - (1+r_D)D}{n(1+r_E)} \\ &= \frac{(1+r_{A2})\Delta A - (1+r_D)\Delta D}{(n+1)(1+r_E)} - \frac{(1+r_{A1})A - (1+r_D)D}{n(n+1)(1+r_E)}\end{aligned} \quad \text{(E8)}$$

r_{A1} - the rate of return on existing A expected by managers.

r_{A2} - the rate of return on the additional investment expected by managers.

This expression is the difference between the present value with and without the issuance of an additional share. Managers can increase the present value of share price by issuing an additional share if ΔPV is positive.

Substituting E6 and E7 into E8,

$$\begin{aligned}\Delta PV = [&(n+1)\{r_{A2} - kr_E - (1-k)r_D\}\{(1+r_{A1})A - (1+r_D)D\} \\ &- (r_{A2}-s_{A2})\{(1+r_{A1})A - (1+r_D)D\} \\ &- n(r_{A1}-s_{A1})\{(1+r_{A2}) - (1-k)(1+r_D)\}] \; / \\ &[n(n+1)(1+r_E)\{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_D)\}]\end{aligned} \quad \text{(E9)}$$

If there is no asymmetric information, i.e., $r_{A1} = s_{A1}$ and $r_{A2} = s_{A2}$, E9 becomes

$$\Delta PV = [\{r_{A2} - kr_E - (1-k)r_D\}\{(1+r_{A1})A - (1+r_D)D\}] / [n(n+1)(1+r_E)\{(n+1)k(1+r_E) - (1+r_{A2}) + (1-k)(1+r_D)\}] \quad \text{(E10)}$$

Then

$$\Delta PV \geq 0 \quad \text{if } r_{A2} \geq kr_E + (1 - k)r_D \quad \text{(C1)}$$

In words, the present value of the expected share price increases as long as the expected return from the additional investment is greater than the weighted average cost of capital. The minimum weight, k, is set by regulators.

When the Modigliani-Miller theorems are combined with the option pricing model [Hsia (1981)],

$$r_E = \rho + (\rho - r_M)(1 - k)/k$$

where ρ is the cost of equity for an all-equity firm of a given risk class, and r_M is the cost of debt determined based on the riskiness of the firm. Substituting this expression into C1,

$$WACC = \rho - (1 - k)(r_M - r_D) \quad \text{(E11)}$$

If r_D is market determined ($r_D = r_M$), the WACC is independent of capital structure (k). However, assuming the deposit insurance premium is underpriced ($r_M > r_D$), the WACC increases with k. In other words, a higher proportion of equity financing results in a decreased option value deriving from the deposit insurance. However, WACC will never exceed ρ in this case. Thus, although a higher capital requirement may make banks more selective about investment projects, it cannot make them overly selective.

If $r_{A1} > s_{A1}$ and $r_{A2} = s_{A2}$, then E9 becomes

$$\begin{aligned} \Delta PV = & [(n+1)\{r_{A2} - kr_E - (1-k)r_D\}\{(1+r_{A1})A - (1+r_D)D\} \\ & - n(r_{A1}-s_{A1})\{(1+r_{A2}) - (1-k)(1+r_D)\}] \; / \\ & [n(n+1)(1+r_E)\{(n+1)k(1+r_E) - (1+r_{A2}) + (1-k)(1+r_D)\}] \end{aligned} \tag{E12}$$

Hence,

$\Delta PV \geq 0$ if

$$r_{A2} \geq kr_E + (1-k)r_D + \frac{n(r_{A1}-s_{A1})\{(1+r_{A2}) - (1-k)(1+r_D)\}}{(n+1)\{(1+r_{A1})A - (1+r_D)D\}} \tag{C2}$$

When the stock market is pessimistic about the return from the bank's existing investments, equity financing becomes expensive. Thus, the overall funding cost increases. In this case, unless the bank finds an investment opportunity that is profitable enough to compensate for the funding cost disadvantage arising from the capital requirement, undertaking investment will dilute the value of existing shares. Then the bank may pass up reasonably profitable investment opportunities that may be undertaken by other institutions.

If $r_{A1} = s_{A1}$ and $r_{A2} > s_{A2}$, E9 becomes

$$\begin{aligned} \Delta PV = & [(n+1)\{r_{A2} - kr_E - (1-k)r_D\}\{(1+r_{A1})A - (1+r_D)D\} \\ & - (r_{A2}-s_{A2})\{(1+r_{A1})A - (1+r_D)D\}] \; / \\ & [n(n+1)(1+r_E)\{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_D)\}] \end{aligned} \tag{E13}$$

Then

$\Delta PV \geq 0$ if

$$r_{A2} \geq kr_E + (1-k)r_D + \frac{r_{A2} - s_{A2}}{n+1} \qquad \text{(C3)}$$

The result is similar when the stock market underestimates the return from the additional investment. The capital requirement narrows the scope of profitable investment opportunities for the bank.

Case 2: The bank finances a new investment that is subject to the capital requirement with newly raised capital from issuing an additional share and assets that are not subject to capital requirements.

The price of the additional share,

$$P = \frac{(1+s_{A1})A + (1+s_{A2})\Delta A + (1+r_B)B + (1+r_B)\Delta B - (1+r_D)D}{(n+1)(1+r_E)} \qquad \text{(E2a)}$$

$$\Delta A = \frac{P}{k} \qquad \text{(E3a)}$$

$$\Delta B = -\frac{P}{k} + P \qquad \textit{(E4a)}$$

B is reduced by the increase in A minus the newly raised capital, P.

Solving in the same way,

$$\begin{aligned} \Delta PV = {} & [(n+1)\{r_{A2} - kr_E - (1-k)r_B\}\{(1+r_{A1})A + (1+r_B)B - (1+r_D)D\} \\ & - (r_{A2} - s_{A2})\{(1+r_{A1})A + (1+r_B)B - (1+r_D)D\} \\ & - n(r_{A1} - s_{A1})\{(1+r_{A2}) - (1-k)(1+r_B)\}] \; / \\ & [n(n+1)(1+r_E)\{(n+1)k(1+r_E) - (1+s_{A2}) + (1-k)(1+r_B)\}] \end{aligned} \qquad \text{(E9a)}$$

If there is no asymmetric information, i.e., $r_{A1} = s_{A1}$ and $r_{A2} = s_{A2}$, then

$$\Delta PV \geq 0 \quad \text{if } r_{A2} \geq kr_E + (1 - k)r_B. \tag{C1a}$$

If $r_B = r_D$, say both are the risk-free rate of return, the existence of B does not affect the investment decision of the bank. However, if $r_B > r_D$ due to incorrect risk weighting (e.g., ignoring the interest risk of government securities), the opportunity cost of investment in high-risk-weight assets is higher. Then the bank may limit investment in A to highly profitable opportunities. The incorrect risk weighting will present the bank with an advantage in pursuing growth since it is profitable to invest deposits in B. The direction of growth, however, will be biased toward B.

If $r_{A1} > s_{A1}$ and $r_{A2} = s_{A2}$, then

$\Delta PV \geq 0$ if

$$r_{A2} \geq kr_E + (1-k)r_B + \frac{n(r_{A1} - s_{A1})\{(1+r_{A2}) - (1-k)(1+r_B)\}}{(n+1)\{(1+r_{A1})A + (1+r_B) - (1+r_D)D\}} \tag{C2a}$$

If $r_{A1} = s_{A1}$ and $r_{A2} > s_{A2}$, then

$\Delta PV \geq 0$ if

$$r_{A2} \geq kr_E + (1-k)r_B + \frac{r_{A2} - s_{A2}}{n+1} \tag{C3a}$$

The effects of information asymmetry are similar to those in case 1. Equity financing raises the weighted average cost of capital when the stock market is pessimistic about the future earnings prospects of the bank.

This analysis shows that the WACC of a bank increases with the proportion of equity needed to finance a new project. In the absence of information asymmetry, although the

capital requirement affects the investment decision of banks, it does not handicap banks relative to other institutions. Hence, information asymmetry is the major factor that causes the capital requirement to restrain banks from pursuing profitable investment opportunities.

3. Empirical Estimation

The previous section has recognized main factors that cause the capital requirement to affect the investment decision of banks: decreased proportions of cheap deposit financing, excessively high costs of equity financing due to information asymmetry, and incorrect risk weighting. Due to these factors, the weighted average cost of capital (WACC) rises with equity financing. This section examines cross-sectional differences in the growth of risk-weighted assets to evaluate the roles of underpriced deposit financing and information asymmetry. Particular attention will be paid to asymmetric information that can unduly restrain banks form pursuing profitable investment opportunities. Incorrect risk-weighting should not cause any cross-sectional differences.

When the capital requirement is tightened, banks need to use more equity to finance investment. The need for additional equity to finance a marginal investment may be related to the gap between the actual and required capital ratio. While banks with more capital than required can undertake an additional investment without increasing the proportion of equity financing, banks constrained by the higher capital requirement need to increase the proportion of equity financing for an additional investment. Thus, a higher capital requirement causes larger increases in the WACC for banks with lower capital ratios. This relationship should hold among banks that are not constrained by the capital requirement, as well as constrained banks. Many banks may want to maintain some excess capital to

avoid difficulties in the future. Thus, there should be a positive relationship between the capital ratio of a bank and growth of its risk-weighted assets. In addition, the relationship is expected to be more pronounced for banks whose stocks are underpriced due to information asymmetry because the cost of equity is higher for those banks.

3.a. Data

The sample of this study consists of the highest bank holding companies (bank holding companies not owned by other bank holding companies) with $150 million or more in consolidated assets. The main data source is the Y-9C Reports compiled by the Federal Reserve Board. The reports can be regarded as the bank holding company's counterpart of the Bank Call Reports (Consolidated Reports of Condition and Income). The Y-9C Reports offer fairly detailed financial information, including financing activities and information necessary to calculate the risk-weighted assets.[4] However, the reports do not include stock prices. The Y-9C Reports data are merged with the stock price data compiled by SNL Securities. The stock price data include all publicly traded stocks of bank holding companies. In addition, the analysis incorporates the data on the employment condition at the state level compiled by the Bureau of Labor Statistics.

Some observations that are believed to contaminate the analysis have been eliminated from the sample. Since the stock prices of merger targets tend to behave abnormally, merger targets announced in 1991 have been excluded. I have also eliminated bank holding companies that grew by more than 100 percent in 1991. It may not be a

[4]The information necessary to calculate the risk-weighted assets has become available since the third quarter of 1990. The calculation of risk-weighted assets is based on the Capital Adequacy Guidelines prepared by the Federal Reserve Board.

meaningful attempt to explain the behavior of a bank holding company merged with a larger one using the before-merger financial structure. In addition, observations have been dropped when the calculated financial ratios raise a strong suspicion of accounting errors (e.g., the ratio of cash dividends declared on common stock to the value of common stock greater than 1) .

3.b. Specification

This section attempts to explain the cross-sectional variation in the growth of risk-weighted assets between the end of 1990 and the end of 1991. The adjustment of risk-weighted assets may have started earlier, but for years prior to 1990, risk-weighted assets cannot be calculated from the Y-9C Reports. The focus is on the effect of the Basle Agreements of 1988 on the investment behavior of banks and on the significance of information asymmetry and underpriced deposits in causing the capital requirement to limit the growth.

The main equation to be estimated is the following:[5]

$$RRWA = a_1 + \underset{(+)}{a_2 CAPITAL} + \underset{(-)}{a_3 CAPITAL^2} + \underset{(+)}{a_4 STOCK} + \underset{(-)}{a_5 DIVIDEND}$$

$$+ \underset{(-)}{a_6 TREASURY} + \underset{(+)}{a_7 SIZE} + \underset{(+)}{a_8 EOA} + \underset{(?)}{a_9 VOLATILE} + \underset{(-)}{a_{10} CORE}$$

$$+ \underset{(+)}{a_{11} ECONOMY} + \underset{(?)}{a_{12} GROWTH}$$

RRWA - The change in the ratio of risk-weighted assets to total assets [(risk-weighted assets / total assets at the end of 1991) - (risk-weighted assets / total assets at the

[5]The signs in the parenthesis are expected signs.

end of 1990)].

Changes in total risk-weighted assets can be driven by mergers and acquisitions. RRWA, which reflects portfolio reshuffling between assets of different risk weights, can resolve the problem arising from mergers and acquisitions.[6] A larger RRWA for a bank holding company means that the bank holding company increased risk-weighted assets after adjusting for the growth of total assets. In addition to adjusting for mergers and acquisitions, RRWA is more appropriate in analyzing banks' responses to the tightened capital requirement than the growth of total risk-weighted assets, assuming that banks do not exercise much control over the size of their liabilities in the short run.

CAPITAL - the ratio of tier 1 plus tier 2 capital to risk-weighted assets at the end of 1990. Tier 1 plus tier 2 capital is chosen over tier 1 capital since more banks appear to have had problems with meeting the tier 1 plus tier 2 capital requirement (Table 1). Well-capitalized banks can undertake a new investment under a tightened capital requirement without significantly changing their desired mix of equity and debt. Thus, the investment decision of banks with more capital should be less restrained by the minimum capital requirement. The square of the capital ratio is included since the relationship between the capital ratio and asset growth is likely to be nonlinear. In other words, the difference in the capital ratio may not matter much among banks with comfortable capital ratios.

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[6]Given that the sample consists of highest bank holding companies, it is not practical to eliminate the bank holding companies involved in mergers and acquisitions. A highest bank holding companies may own other bank holding companies that may also own other bank holding companies as well as banks. Apart from the difficulty of tracing merger and acquisition activities, the loss of sample is too large if we eliminate highest bank holding companies on the basis of mergers and acquisitions at lower levels.

STOCK - the rate of change in the stock price of bank holding companies [(Price at the end of the current year - Price at the end of the previous year) / Price at the end of the previous year].

A significant rise in stock price may be due to the stock market's learning of favorable information possessed by management. Similarly, revelation of unfavorable information will result in a sharp drop in stock price. Thus, if the transmission of information is a main cause for stock price movements, there should be a positive relationship between changes in stock price and investment activities. Both the price change during 1990 (STOCK90) and that during 1991 (STOCK91) are included.

DIVIDEND - The ratio of cash dividends declared on common stock in 1990 to the value of common stock at the end of 1990.

Miller and Rock (1985) argues that a major purpose for a firm to pay out dividends is to signal favorable future earnings prospects to the stock market. Given this signalling effect, managers with more favorable information unknown to the market have an incentive to pay more dividends. Assuming the information problem is not completely solved, though abated, by the dividend signal, more dividends may mean more information asymmetry and slower growth in the following period. In the case of commercial firms that are constrained by liquidity, this variable will hardly capture information asymmetry. A large dividend reduces liquid assets and hence results in slower growth. For financial intermediaries, however, the availability of liquid assets is less likely to be a major factor affecting investment. In addition, the availability of funds should not affect the ratio of risk-weighted assets to total assets, though it may affect the growth of total risk-weighted assets. Thus, this variable,

when controlled for capital adequacy, can capture information asymmetry.

TREASURY - the net purchase of treasury stock in 1990 divided by common stock.

When stock is underpriced due to asymmetric information, managers can increase the per share value of stock by purchasing back some shares at a low price. Then the purchase of treasury stock can be a sign of information asymmetry.

SIZE - natural log of total assets at the end of 1990.

Since larger banks are better known to the stock market, they may suffer less information asymmetry.

EOA - before-tax earnings on assets in 1990.

Current earnings may signal future earnings prospects and reduce information asymmetry.

VOLATILE - the standard deviation of annual EOA of the years between 1986 and 1991.

High volatility of EOA may make it difficult for the stock market to estimate future earnings prospects and hence increase the possibility of information asymmetry. On the other hand, managers of a bank with highly volatile earnings may be aggressive risk-takers. These two effects, working into opposite directions, make the expected sign ambiguous.

CORE - the proportion of core deposits (transactions accounts and savings accounts) to total assets at the end of 1990.

Assuming core deposits are less sensitive to interest rates, a smaller portion of the subsidy provided by the deposit insurance is passed on to core depositors than that passed on to more interest-sensitive time depositors. Thus, deposits are likely to be more heavily underpriced for banks with more core deposits, i.e., the average cost of deposits (r_D) may be lower. Thus, the tightened capital requirement, which restricts the use of underpriced

deposits, should have larger impact on the investment decision of banks with more core deposits.[7] Differentiating E11 with respect to k (the required capital ratio),

$$\frac{\partial WACC}{\partial k} = r_M - r_D$$

When the gap between the interest rate incorporating risk premiums (r_M) and the actual interest rate on deposits is larger, the required rate of return on the marginal investment increases faster as the proportion of equity financing increases.

ECONOMY - the rate of growth in non-farm payroll employment during 1991 in the state where the headquarter of the bank holding company is located.

This variable intends to capture the abundance of profitable investment opportunities (projects with high r_{A2}). There should be more profitable investment opportunities in a growing economy. Holding the funding cost constant, bank holding companies with more investment opportunities will grow faster.

GROWTH - the rate of growth of total assets between the end of 1990 and the end of 1991. It may be difficult to maintain the same portfolio composition for a bank that rapidly

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[7]Assuming away asymmetric information, underpriced debt is the major reason why the capital requirement matters. If the deposits of a bank were not underpriced in the first place, changed mix of equity and debt should not change the WACC of the bank. Then a changed capital requirement would not affect the investment behavior of the bank. On the other hand, an increased proportion of equity financing in response to the tightened capital requirement significantly raises the WACC of banks with heavily underpriced debt. The *level* of WACC should remain lower for banks with more heavily underpriced deposits under the tightened capital requirement, but the tightening of the capital requirement will induce a larger *change* in the WACC of those banks. Assuming that banks equated their WACC and the return from marginal investment before the change in the capital requirement, a larger change in the WACC induces a larger change in the investment behavior of banks.

expands or contracts. This variable intends to capture a possible *ad hoc* relationship between the asset growth and the change in portfolio composition.

As shown above, this analysis uses the lagged values of most independent variables in order to avoid the simultaneity problem. An exception is STOCK91, which seems to be an important variable *a priori*. The variable can cause a simultaneity problem. The results of regressions, however, are found not to be affected by the exclusion of STOCK91. Heteroskedasticity seems to be a more serious problem. The investment decisions may vary more widely among large banks that engage in more diverse activities. In addition, since banks with comfortable capital ratios can freely choose the rate of growth, their growth rates may show a larger variance. Fast growth may also result in a large shift of portfolio composition. A common treatment for heteroskedasticity is a weighted regression. Given that heteroskedasticity can arise with respect to many variables in this case, it is difficult to accurately specify the structure of heteroskedasticity and obtain an appropriate weight. I use the heteroskedasticity-consistent covariance matrix suggested by White in deriving t values. Table 2 compares the consistent estimates and OLS estimates of the standard deviations. The difference between the two estimates appears to be significant, indicating the presence of heteroskedasticity. Given fairly large sample size of this analysis (more than 200 observations), t values based on the consistent estimates should be unbiased.

3.c. Results

Table 3 shows the estimation results. The estimated coefficients mostly have expected signs. The capital ratio is found to be significant. As expected, the effect of CAPITAL is more significant among bank holding companies with relatively low capital

ratios.[8] The positive relationship between the capital ratio and investment in risk-weighted assets can be explained by both underpriced debt and information asymmetry. Hence, it alone does not constitute evidence of information asymmetry. However, the signs of variables relevant to information asymmetry (STOCK, DIVIDEND, TREASURY, SIZE, and EOA) support the presence of information asymmetry, though low statistical significance prevents a clear conclusion. The statistical significance of DIVIDEND and TREASURY turns out to be fairly high. The significance of TREASURY deserves attention since the variable is believed to be particularly relevant to asymmetric information. Given that the sale and purchase of treasury stock are of temporary nature, TREASURY should well reflect the response of management to the stock market condition in a given period. The negative sign of CORE is consistent with the hypotheses that deposits are underpriced in general and that the WACC of banks with more heavily underpriced deposits is affected more by the capital requirement. ECONOMY turns out to be insignificant. The high activity of interstate acquisitions in the 1980s may have made the economic condition at the state level irrelevant to the growth of bank holding companies.

Table 4 reports the results of regressions using the rate of growth in risk-weighted assets as the dependent variable. The qualitative results are similar to those of the previous regression. A notable exception is the insignificance of DIVIDEND. A possibility is that the liquidity effect discussed above plays a role in determining the growth of total assets even for financial intermediaries. TREASURY, however, continues to be fairly significant.

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[8]Table 7 shows the values of the first derivative with respect to CAPITAL at different capital ratios.

The interpretation of this regression requires more caution since the growth in total risk-weighted assets can be driven largely by mergers and acquisitions.

Table 5 compares the results of estimation using different samples: BHC's with publicly traded stocks (sample 1) and other BHC's (sample 2). The comparison is possible since the exclusion of stock price data does not significantly affect the results of the estimation using sample 1. Estimation using sample 2 shows substantially smaller magnitude of the coefficients of CAPITAL, DIVIDEND, and TREASURY.[9] The statistical significance of those variables is also lower. These findings are consistent with the hypothesis that information asymmetry between managers and the stock market affects the banks' investment decision by raising the cost of equity. BHC's in sample 2 may be owned mainly by managers and a few large investors, who should be well informed about the earnings prospects of the BHC's. Thus, the effect of information asymmetry should be smaller for privately held BHC's. In contrast to low significance of variables reflecting information asymmetry, the effect of CORE is more pronounced in the regression using sample 2. This result suggests that reduced use of underpriced debt, as opposed to asymmetric information, is the main channel through which the tightened capital requirement affect the investment decision of BHC's in sample 2. Appendix 1 reports the results of the Wald test that examines the equality between the coefficient of the variables reflecting information asymmetry in the two regressions. The test does not convincingly reject the equality of the coefficient. However, the test variables have expected signs, and

[9]The smaller effect of CAPITAL may be partly because BHC's in sample 2 are better capitalized (see Table 9), but it does not seem to be enough to explain the large difference in the magnitude of coefficients.

the equality of the coefficient of TREASURY is rejected with a fairly high confidence interval (about 91 percent).

Low statistical significance of many variables raises the possibility that the inclusion of possibly irrelevant variables may have caused some problems such as multicollinearity and inefficiency. Table 6 shows the results of estimation without variables of relatively low statistical significance. The exclusion does not substantially affect either the coefficients or the statistical significance of included variables.

The main empirical results are that BHC's with lower capital ratios made smaller investment in risk-weighted assets and that both information asymmetry and underpriced debt played their roles in determining the investment behavior of BHC's in 1991. Given these results, the tightened capital requirement appears to have slowed down the growth of BHC's. The mechanisms thorough which the capital requirement affects the investment decision are an increased WACC due to a reduced proportion of cheaper deposit financing and a high cost of equity due to asymmetric information. Incorrect risk weighting may also reduce the overall growth of risk-weight assets, but it should not cause cross-sectional variations in the growth rates.

4. Conclusion

The tightened capital requirement appears to have affected the investment decision of banks. The growth of risk-weighted assets slowed down in general, and the slowdown is more pronounced for poorly capitalized banks. In order to understand the implications of this adjustment, we need to know why the capital requirement affects the investment decision of banks.

This paper has recognized two main reasons that the capital requirement alters the investment decision of banks: (1) It reduces the banks' ability to take advantage of deposit financing which is cheaper because of the deposit insurance and (2) The cost of equity can be excessive due to information asymmetry between managers and the stock market. Section 2 also showed that incorrect risk-weighting could slow down the growth of risk-weighted assets. Incorrect risk weighting, however, should not cause cross-sectional variations among banks, and it is not a problem fundamental to the capital requirement itself but a problem with its implementation. While the reduced option value may improve both regulatory and economic efficiency, asymmetric information can be a problem in that it unduly prevents banks from pursuing otherwise profitable investment opportunities.

Empirical results support that both underpriced deposits and information asymmetry contributed to the slow growth of risk-weighted assets after the tightening of the capital requirement. The growth of risk-weighted assets was slower for banks with more heavily underpriced debt. The coefficients of variables reflecting information asymmetry indicate that bank holding companies invested less in high-risk-weight assets when inside information was more favorable than the expectation of the stock market. For bank holding companies whose stocks were not publicly traded, capital adequacy and other variables reflecting information asymmetry turned out to be less significant. This result also underscores the importance of information asymmetry between managers and the stock market.

Inferring from the estimated effects of variables reflecting asymmetric information, it is not likely that the negative aspect of the capital requirement arising from information asymmetry outweighs its positive effect of limiting the risk taking of banks. Yet it may be

desirable to make efforts to mitigate the negative effect of asymmetric information by implementing the capital requirement in a flexible manner. For example, regulators may allow more time to meet the capital requirement for banks that have insufficient capital but have sound asset portfolios.

Table 1: The Distribution of the Capital Ratio

	Tier 1	Tier 1 plus tier 2
Mean	0.1160	0.1308
Standard Deviation	0.0680	0.0665
1 percentile	0.0268	0.0419
5 percentile	0.0508	0.0728
10 percentile	0.0631	0.0831
25 percentile	0.0816	0.0992
50 percentile	0.1049	0.1196
75 percentile	0.1353	0.1477
90 percentile	0.1703	0.1821
95 percentile	0.2010	0.2118
99 percentile	0.3930	0.4056

Sample Size: 1019

Table 2: Standard Deviations of Estimated Coefficients

	Consistent Estimate	OLS Estimate	Percentage Difference
INTERCEPT	0.0701	0.0670	4.6
CAPITAL	0.4973	0.5399	8.6
$CAPITAL^2$	1.5527	1.8155	16.9
STOCK90	0.0215	0.0215	0.0
STOCK91	0.0066	0.0077	16.7
DIVIDEND	0.0374	0.0351	6.6
TREASURY	0.0580	0.0786	35.5
SIZE	0.0027	0.0026	3.8
EOA	0.4080	0.4238	3.9
VOLATILE	0.8802	0.9252	5.1
CORE	0.0326	0.0334	2.5
ECONOMY	0.1812	0.2331	28.6
GROWTH	0.0404	0.0252	60.3

Table 3: Regression Results

Dependent Variable: The change in the ratio of risk-weighted assets to total assets

	Model 1	Model 2
INTERCEPT	-0.1124	-0.1170
	(-1.60)	(-1.72)
CAPITAL	1.0823	1.1111
	(2.18)	(2.24)
$CAPITAL^2$	-3.4767	-3.5712
	(-2.24)	(-2.31)
STOCK90	0.0196	0.0188
	(0.91)	(0.89)
STOCK91	0.0021	
	(0.33)	
DIVIDEND	-0.0584	-0.0590
	(-1.56)	(-1.59)
TREASURY	-0.1436	-0.1417
	(-2.48)	(-2.42)
SIZE	0.0023	0.0025
	(0.83)	(1.00)
EOA	0.3418	0.3342
	(0.84)	(0.81)
VOLATILE	0.8896	0.8136
	(1.01)	(0.96)
CORE	-0.0367	-0.0366
	(-1.12)	(-1.12)
ECONOMY	-0.0213	-0.0065
	(-0.12)	(-0.04)
GROWTH	-0.0609	-0.0599
	(-1.51)	(-1.52)
R-Square	0.0882	0.0879
Observations	233	233

Table 4: Regression Results

Dependent Variable: The rate of growth in risk-weighted assets

	Model 3	Model 4
INTERCEPT	0.0255	-0.0466
	(0.12)	(-0.21)
CAPITAL	2.0273	2.5139
	(1.55)	(2.06)
$CAPITAL^2$	-7.6972	-9.3038
	(-1.93)	(-2.52)
STOCK90	0.1001	0.0884
	(1.51)	(1.33)
STOCK91	0.0351	
	(1.63)	
DIVIDEND	0.0167	0.0106
	(0.21)	(0.13)
TREASURY	-0.2802	-0.2502
	(-1.86)	(-1.62)
SIZE	-0.0047	-0.0005
	(-0.47)	(-0.05)
EOA	3.2152	3.1409
	(2.85)	(2.71)
CORE	-0.0887	-0.0874
	(-1.17)	(-1.12)
ECONOMY	-0.8572	-0.6250
	(-1.35)	(-1.05)
VOLATILE	-4.4613	-5.8411
	(-2.05)	(-2.85)
R-Square	0.2162	0.2068
Observations	233	233

Table 5: Regression Results

Dependent Variable: The change in the ratio of risk-weighted assets to total assets

	Model 5	Model 6[a]
INTERCEPT	-0.1253	-0.0679
	(-1.63)	(-0.75)
CAPITAL	1.1326	0.2399
	(2.15)	(1.81)
$CAPITAL^2$	-3.5867	-0.2360
	(-2.17)	(-1.03)
DIVIDEND	-0.0588	-0.0400
	(-1.54)	(-1.50)
TREASURY	-0.1374	-0.0237
	(-2.17)	(-0.85)
SIZE	0.0026	0.0049
	(0.85)	(0.78)
EOA	0.5233	0.2405
	(1.20)	(0.78)
VOLATILE	0.7896	-0.4519
	(0.90)	(-0.89)
CORE	-0.0398	-0.0656
	(-1.17)	(-2.03)
ECONOMY	0.0567	-0.0719
	(0.29)	(-0.43)
GROWTH	-0.0582	-0.1000
	(-1.20)	(-3.86)
R-Square	0.0847	0.0627
Observations	233	349

[a]Model 5 - Bank holding companies with publicly traded stocks.
Model 6 - Other bank holding companies.

Table 6: Regression Results

Dependent Variable: The change in the ratio of risk-weighted assets to total assets

	Model 7	Model 8[a]
INTERCEPT	-0.0808	-0.0143
	(-2.12)	(-0.68)
CAPITAL	1.1984	0.2841
	(2.43)	(2.32)
$CAPITAL^2$	-3.7504	-0.3125
	(-2.29)	(-1.52)
DIVIDEND	-0.0406	-0.0355
	(-1.26)	(-1.39)
TREASURY	-0.1310	-0.0228
	(-2.14)	(-0.86)
CORE	-0.0496	-0.0612
	(-1.64)	(-1.90)
GROWTH	-0.0534	-0.0922
	(-1.27)	(-4.11)
R-Square	0.0699	0.0599
Observations	233	349

[a]Model 7 - Bank holding companies with publicly traded stocks.
Model 8 - Other bank holding companies.

Table 7: First Derivative with Respect to CAPITAL

Capital Ratio	Model 1	2	3	4	5	6	7	8
0.05	0.735	0.754	1.258	1.584	0.203	0.774	0.265	0.823
0.06	0.665	0.683	1.104	1.397	0.198	0.702	0.258	0.748
0.07	0.596	0.611	0.950	1.211	0.193	0.630	0.251	0.673
0.08	0.526	0.540	0.796	1.025	0.188	0.559	0.244	0.598
0.09	0.456	0.468	0.642	0.839	0.183	0.487	0.237	0.523
0.10	0.387	0.397	0.488	0.653	0.178	0.415	0.230	0.448
0.11	0.317	0.325	0.334	0.467	0.173	0.344	0.222	0.373
0.12	0.248	0.254	0.180	0.281	0.168	0.272	0.215	0.298
0.13	0.178	0.183	0.026	0.095	0.163	0.200	0.208	0.223
0.14	0.109	0.111	-0.128	-0.091	0.158	0.128	0.201	0.148
0.15	0.039	0.040	-0.282	-0.277	0.153	0.057	0.194	0.073

Table 8: Descriptive Statistics

Total Assets
(in millions of dollars)

	Sample 1	Sample 2	Sample 3[a]
Mean	8,535	388	3,767
Median	1,827	289	426
Standard Deviation	20,653	322	13,882
Observations	258	364	622

CAPITAL

	Sample 1	Sample 2	Sample 3
Mean	0.1189	0.1344	0.1280
Median	0.1126	0.1252	0.1194
Standard Deviation	0.0324	0.0571	0.0490

DIVIDEND

	Sample 1	Sample 2	Sample 3
Mean	0.1086	0.0789	0.0913
Median	0.0868	0.0530	0.0707
Standard Deviation	0.0909	0.1217	0.1108

TREASURY

	Sample 1	Sample 2	Sample 3
Mean	0.0139	0.0143	0.0141
Median	0.0000	0.0000	0.0000
Standard Deviation	0.0386	0.0614	0.0530

[a]Sample 1 - Bank holding companies with publicly traded stocks.
Sample 2 - Other bank holding companies.
Sample 3 - Combined sample.

Appendix 1: Test of Equality

The following regression results are used to test the equality of the coefficients of the regressions in Table 6.

Dependent Variable: The change in the ratio of risk-weighted assets to total assets

INTERCEPT	-0.0363	CORE	-0.0575
	(-0.86)		(-2.48)
CAPITAL	0.2839	ECONOMY	-0.0074
	(2.27)		(-0.06)
$CAPITAL^2$	-0.3470	GROWTH	-0.0797
	(-1.64)		(-3.38)
DIVIDEND	-0.0406	DUMMY1	0.0302
	(-1.60)		(0.23)
TREASURY	-0.0250	DUMMY2	-0.4956
	(-0.93)		(-0.67)
SIZE	0.0014	DUMMY3	-0.0099
	(0.59)		(-0.24)
EOA	0.4242	DUMMY4	-0.1109
	(1.86)		(-1.71)
VOLATILE	-0.0690		
	(-0.15)		
R-Square	0.0661		
Observations	582		

DUMMY1 is CAPITAL for Sample 1 and 0 for Sample 2.
DUMMY2 is $CAPITAL^2$ for Sample 1 and 0 for Sample 2.
DUMMY3 is DIVIDEND for Sample 1 and 0 for Sample 2.
DUMMY4 is TREASURY for Sample 1 and 0 for Sample 2.

Hypothesis: DUMMY1 = DUMMY2 = 0.
Chi-square value = 2.1342, Probability > 2.1342: 0.3440.
Hypothesis: DUMMY3 = 0.
Chi-square value = 0.0585, Probability > 0.0585: 0.8089.
Hypothesis: DUMMY4 = 0.
Chi-square value = 2.9208, Probability > 2.9208: 0.0874.
Hypothesis: DUMMY1 = DUMMY2 = DUMMY3 = DUMMY4 = 0.
Chi-square value = 6.2947, Probability > 6.2947: 0.1782.

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